TWO DIMENSIONAL ENCODING (CONT'D)

Step 1 vertical mode V(0).

		b1		b2																				
	0	1	1	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1
	0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	1	0	0	0	0	0
a0		a1																						

Step 2 vertical mode $V_L(1)$.

			b1				b2																	
0	1	1	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1
0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	1	0	0	0	0	0	
	a0	a1																						

Step 3 pass mode.

					b1		b2																	
0	1	1	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	0	1	1	1	1
0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	1	0	0	0	0	0	
		a0							a1															

TWO DIMENSIONAL ENCODING (CONT'D)

Step 4 vertical mode $V_L(1)$.

										b1		b2											
0	1	1	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1
0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	1	0	0	0	0	0
							a0		a1														

Step 5 vertical mode V(0).

												b1							b2				
0	1	1	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1
0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	1	0	0	0	0	0
									a0			a1											

TWO DIMENSIONAL ENCODING (CONT'D)

Step 6 horizontal mode white run of 3 and black run of 4

																				b1				b2
0	1	1	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	
0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	1	0	0	0	0	0	
												a0			a1				a2					

Step 7 horizontal mode white run of 5 and a black run of 0.

																				b1				b2
0	1	1	0	0	1	1	0	0	0	1	1	0	0	0	0	0	0	0	0	1	1	1	1	
0	1	0	0	0	0	0	0	0	1	1	1	0	0	0	1	1	1	1	0	0	0	0	0	
																			a0					a1

a2

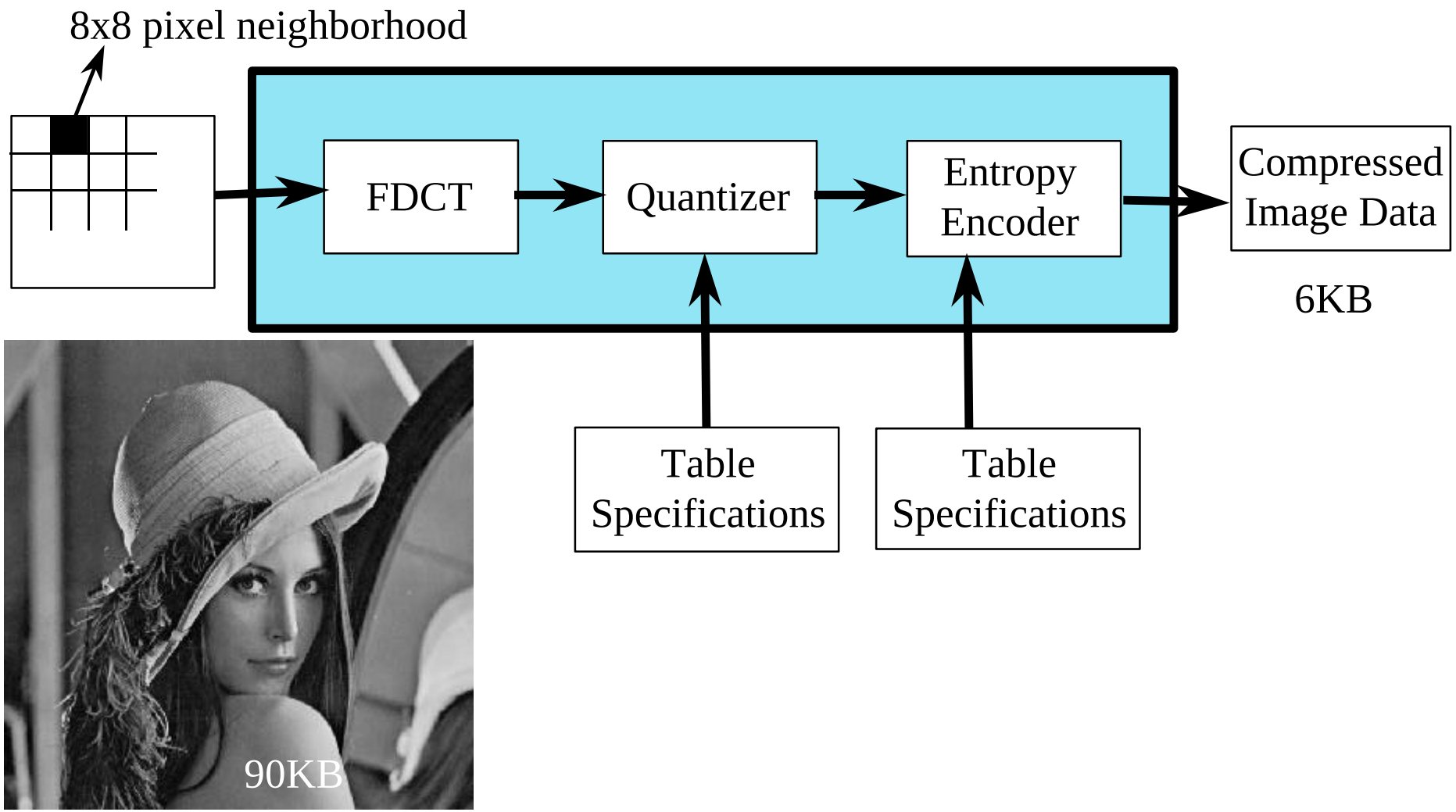
COMPRESSION

JPEG

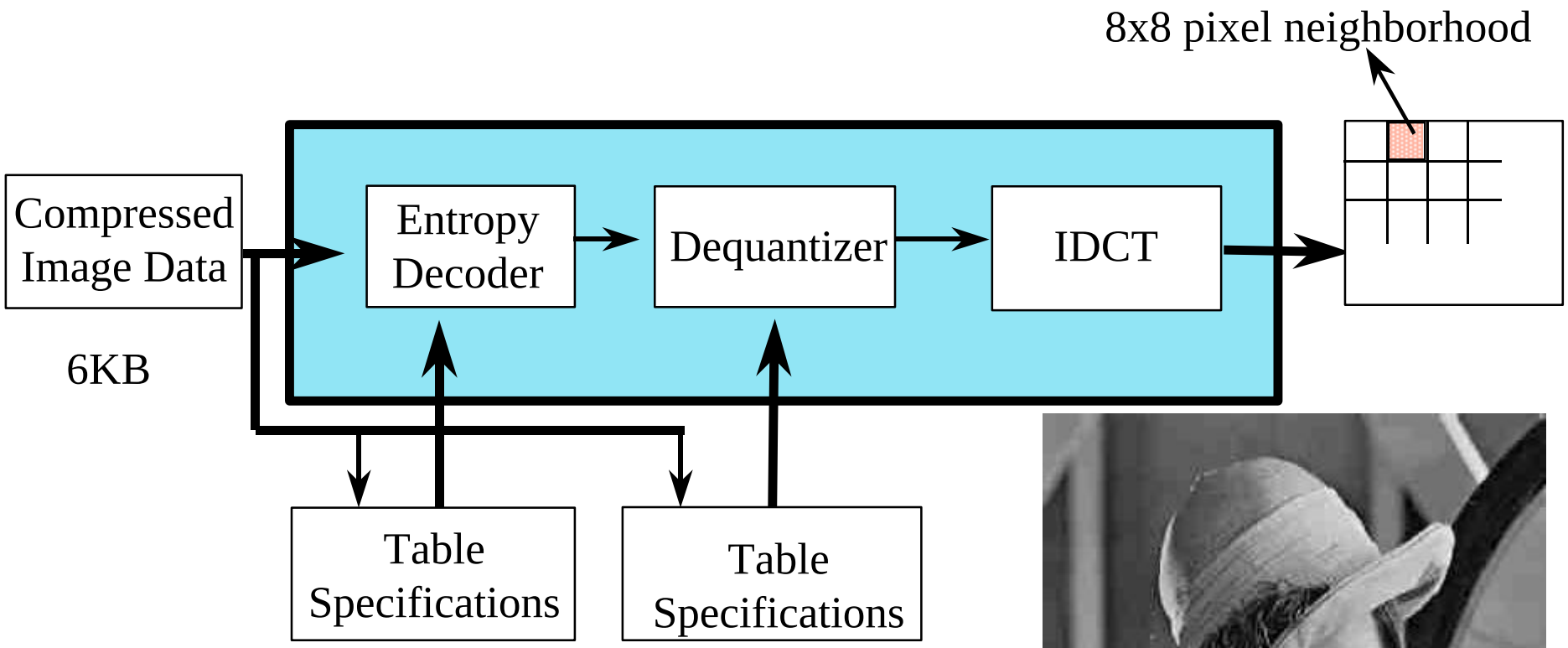
MIL-STD-188-198A

- DCT LOSSY
  - 8-BIT
  - 12-BIT
- LOSSLESS
- DOWNSAMPLE JPEG

DCT - BASED ENCODER JPEG

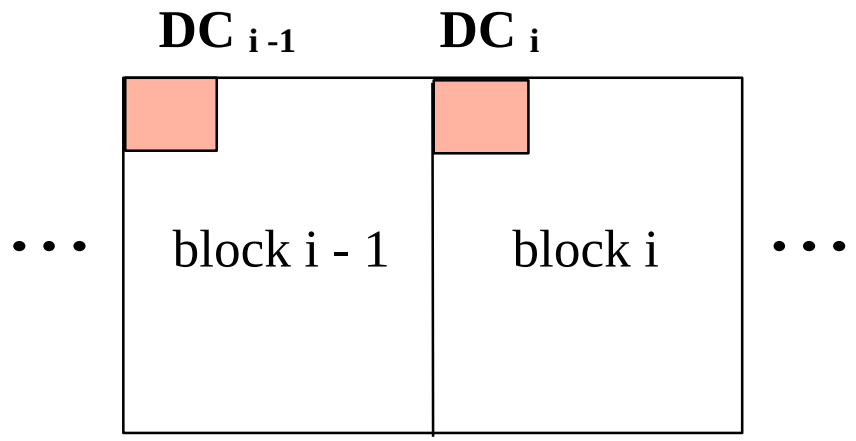


IDCT - BASED DECODER JPEG

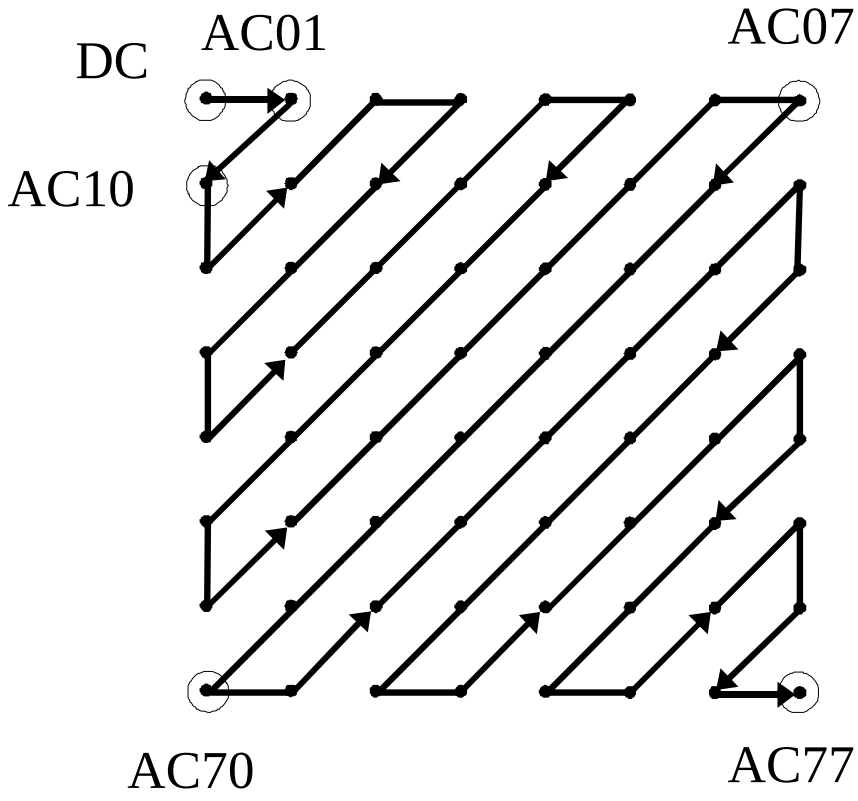


COMPARISON

PREPARATION OF QUANTIZED COEFFICIENTS FOR ENTROPY ENCODING

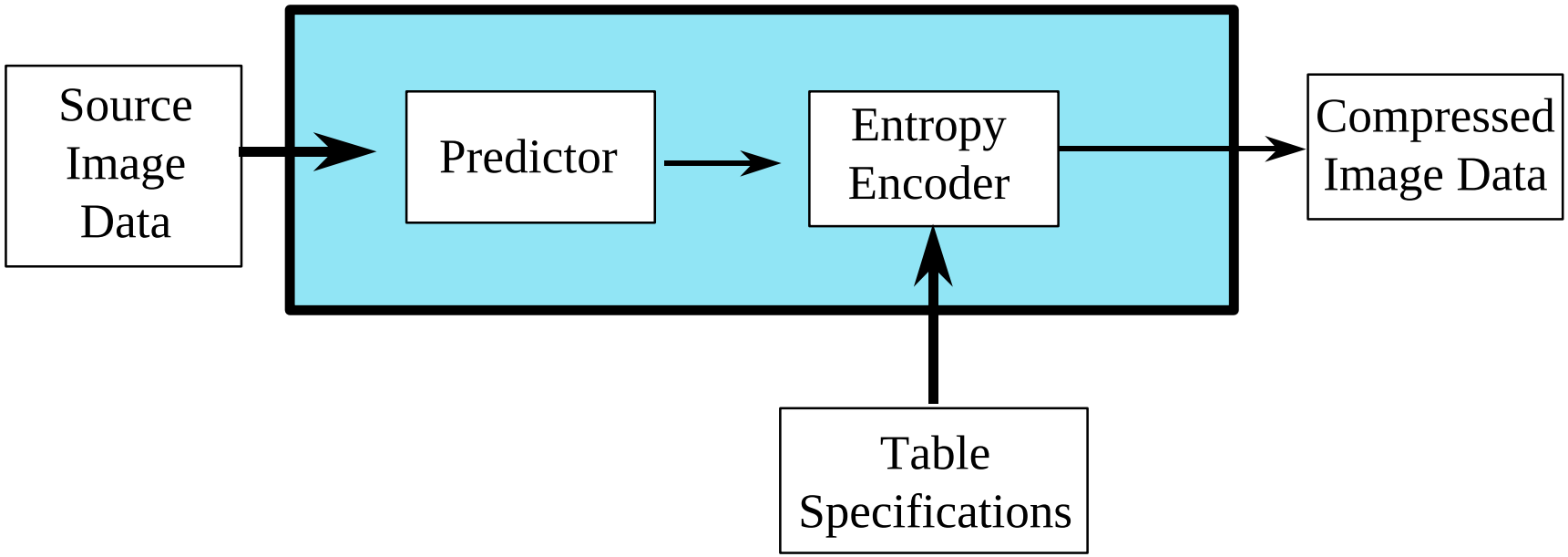


Differential DC Encoding

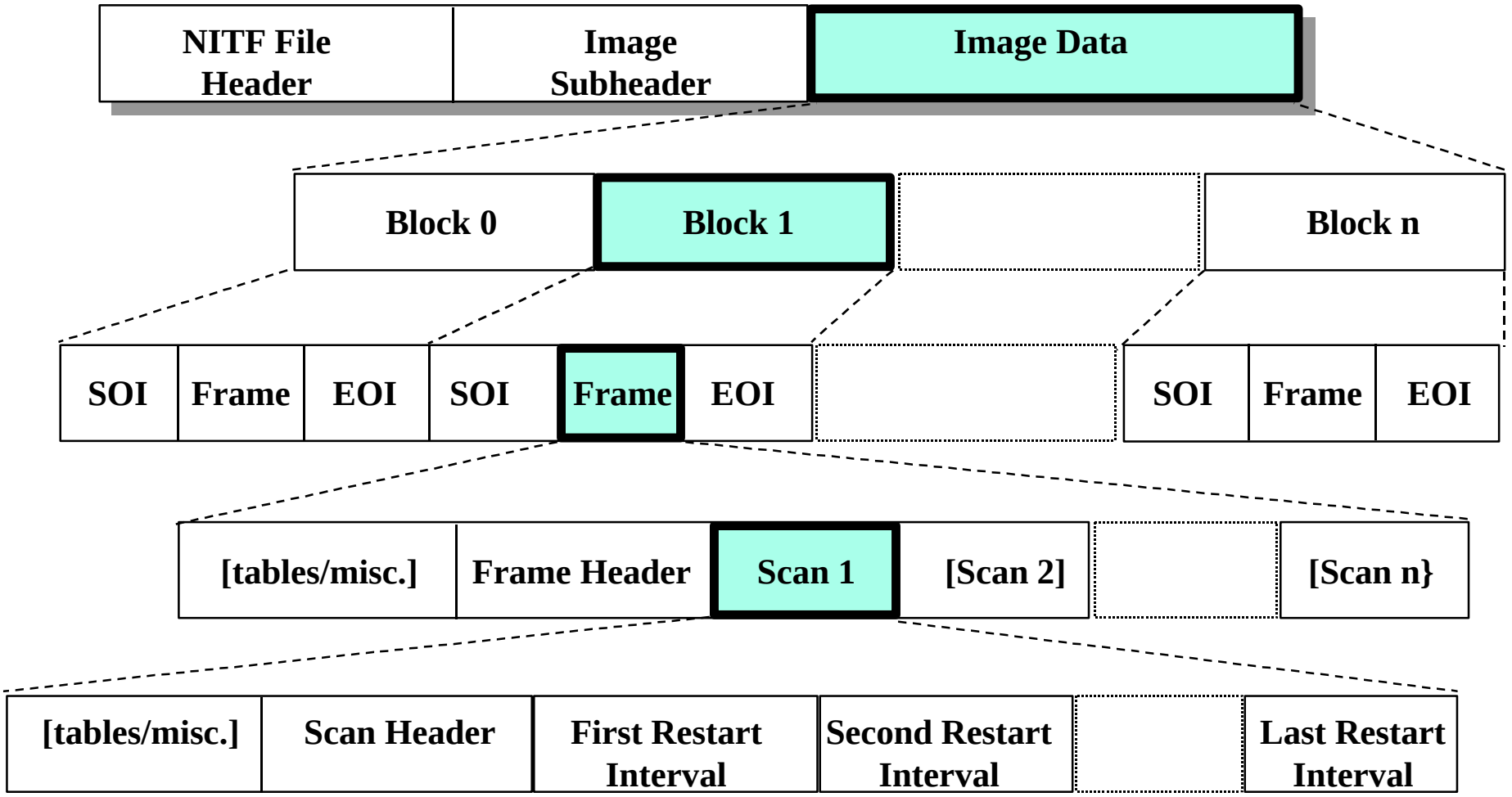


ZIG-ZAG ORDER

LOSSLESS ENCODER

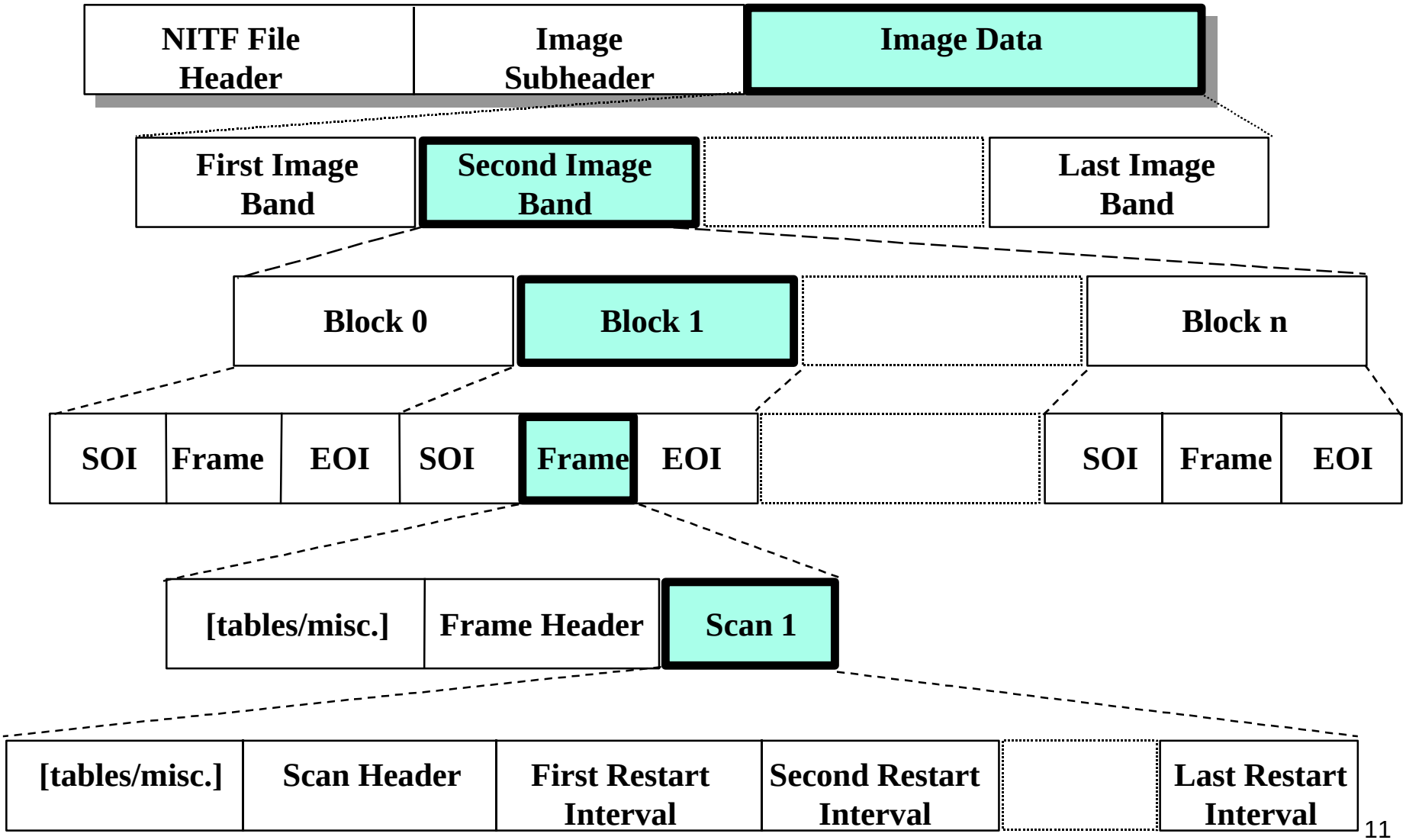


JPEG COMPRESSED NITF MULTIPLE BLOCK FILE STRUCTURE (IMODE B OR P)

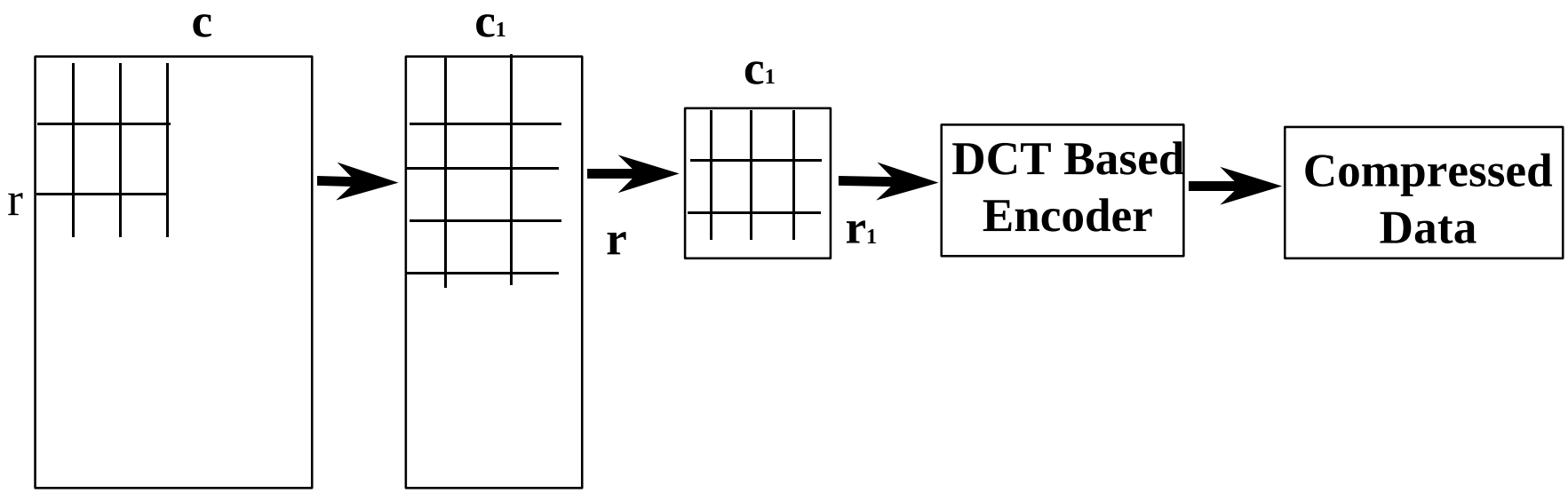


SOI: Start of Image **EOI: End of Image**

JPEG COMPRESSED NITF MULTIPLE BLOCK FILE STRUCTURE IMODE S

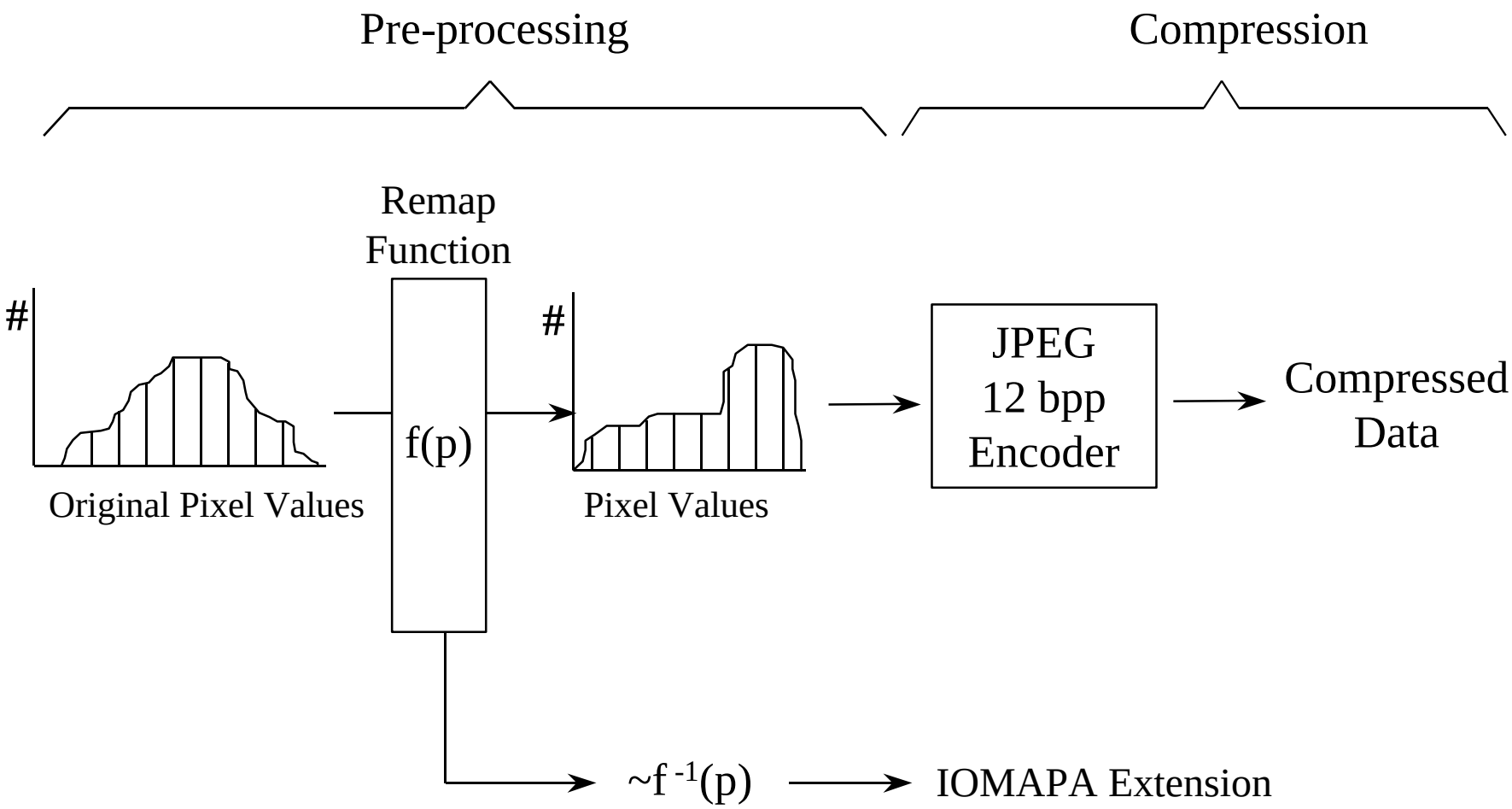


DOWNSAMPLE JPEG

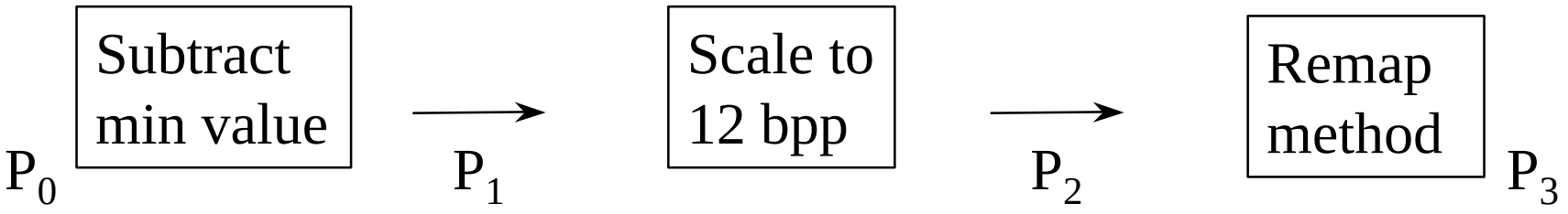


$$\text{Downsampling Ratio} = \frac{r \times c}{r_1 \times c_1}$$

PRE/POST-PROCESSING



REMAPPING FUNCTION



$P_1 = P_0 - P_{min}$

$P_2 = P_1 \times 2^{S_1}$

$(P_2 = P_1 \, LSL(S_1))$

$P_3 = F_{remap(0, 1, 2, 3)}(P_2)$

Remap methods 0, 1, 2 & 3

LSL = Logical Shift Left

REMAP METHODS

0 - No change, unity function. $P_3=P_2$

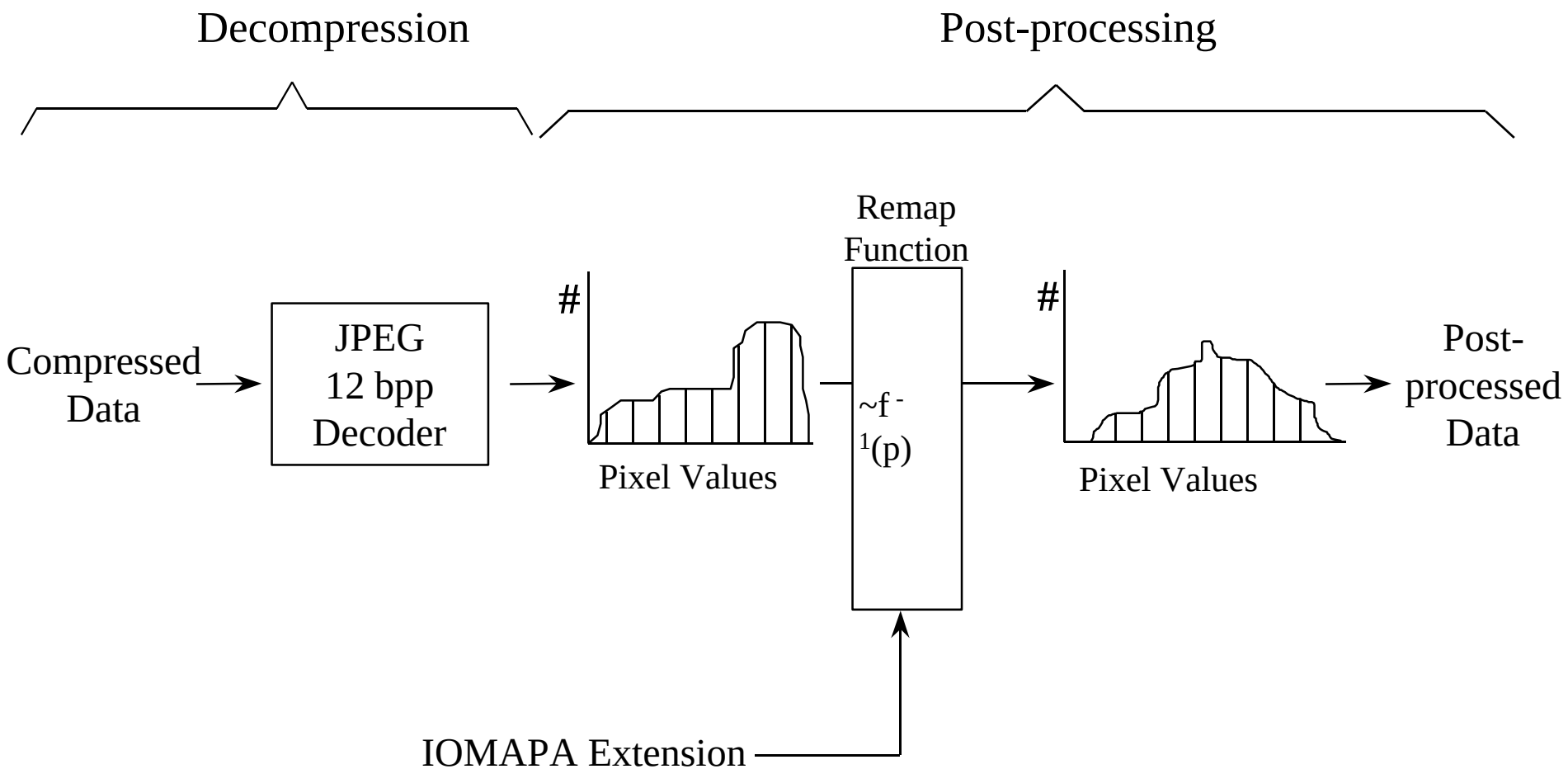
1 - Look-up Table,

P_2	P_3

2 - Logarithmic function, $P_3 = e^{f(P_2)}$

3 - Polynomial function (up to 5th order),
$P_3 = b_0 + b_1P_2 + b_2P_2^2 + b_3P_2^3 + b_4P_2^4 + b_5P_2^5$

PRE/POST PROCESSING

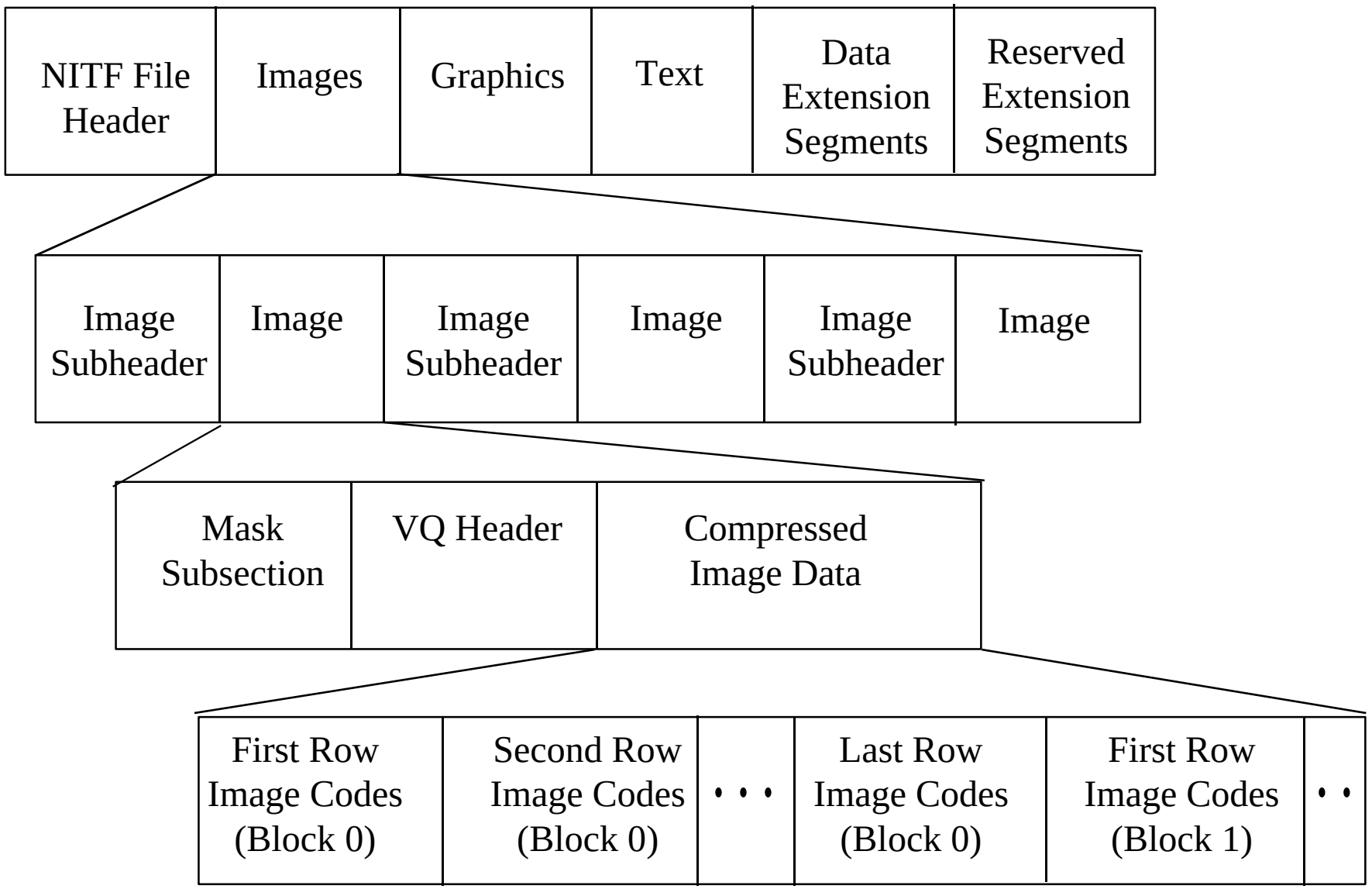


COMPRESSION

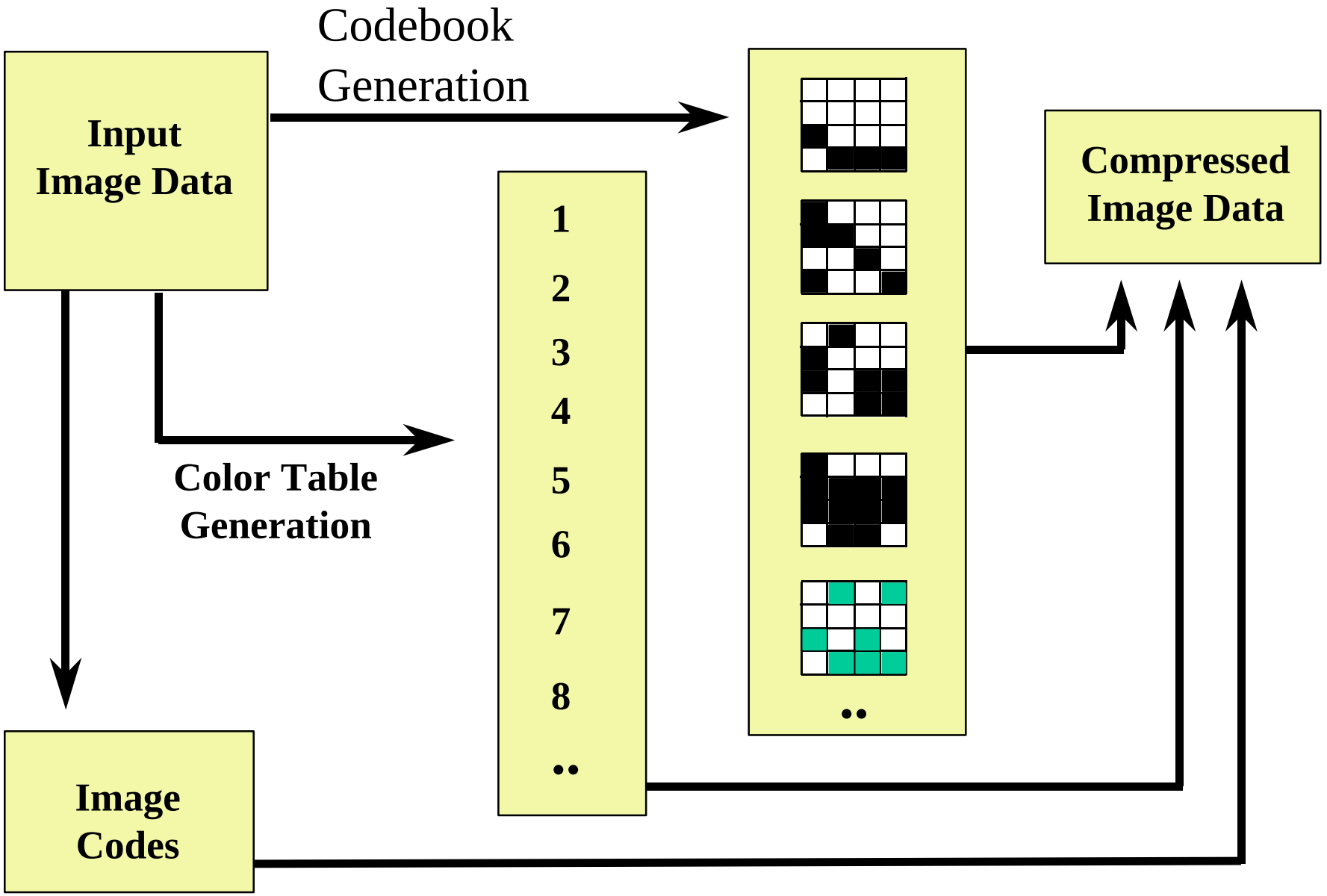
VQ

MIL-STD-188-199

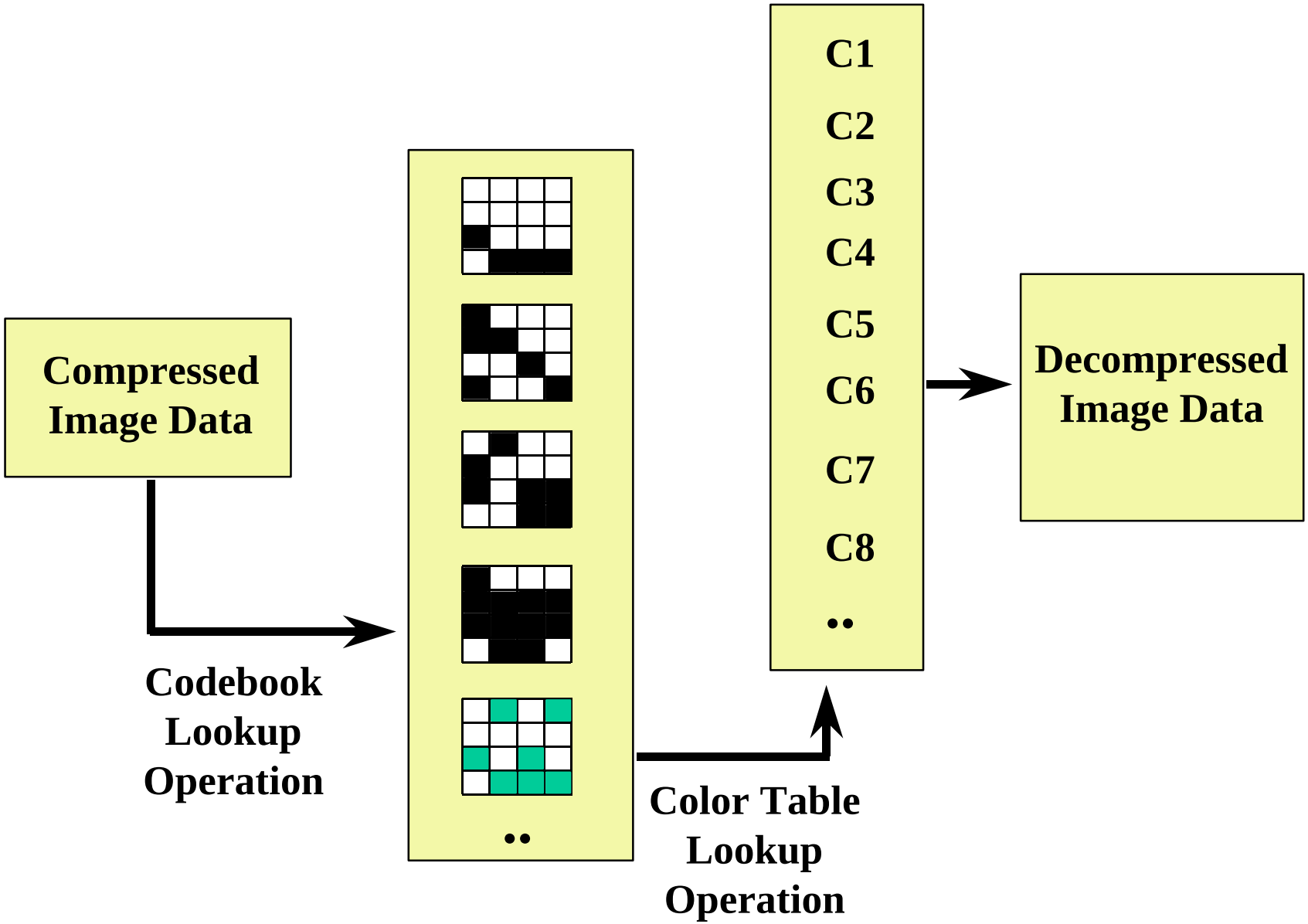
VQ NITF FILE STRUCTURE



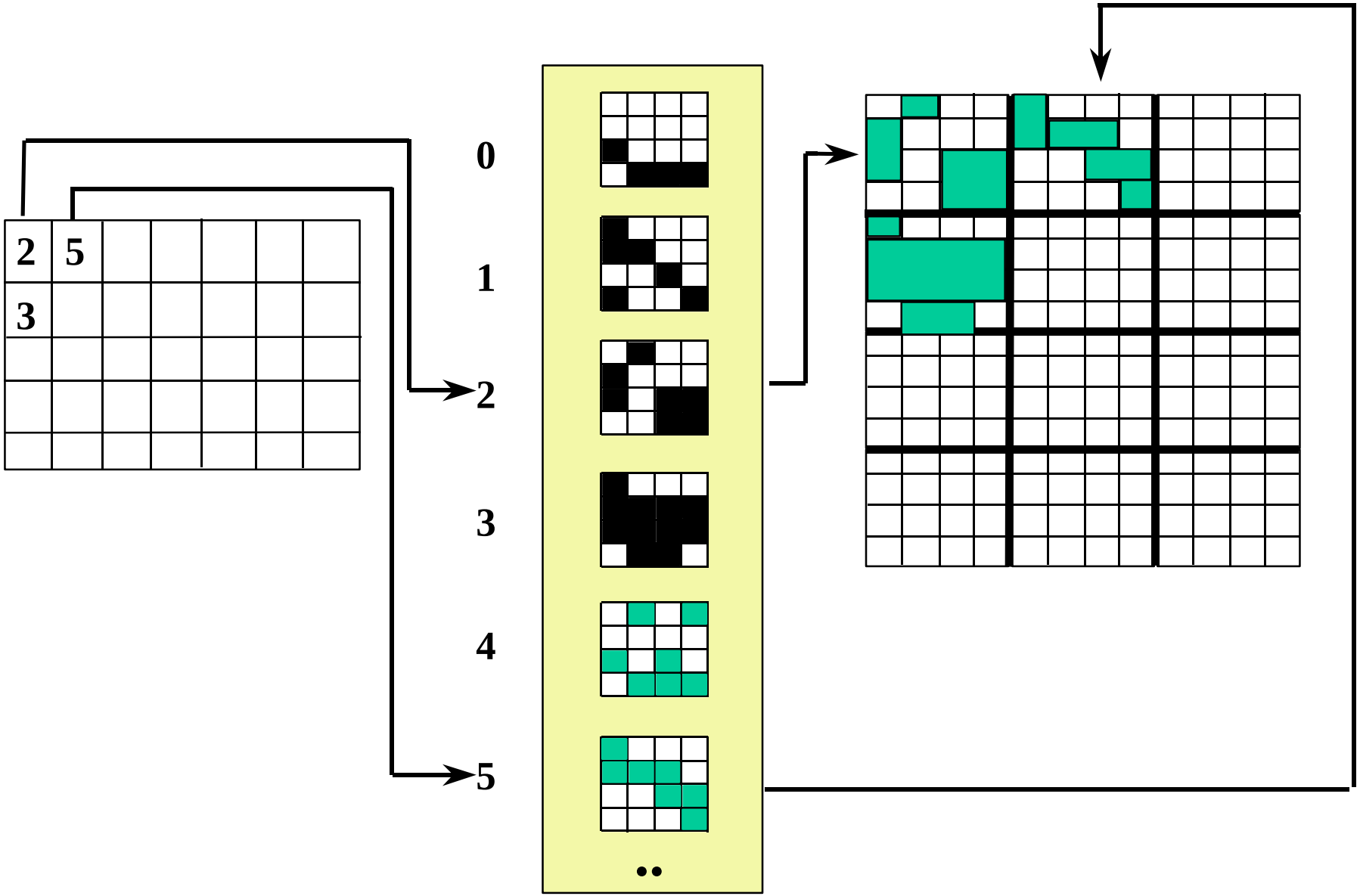
VQ COMPRESSION PROCESS FLOW



DECOMPRESSION PROCESS FLOW



VQ SPATIAL DECOMPRESSION

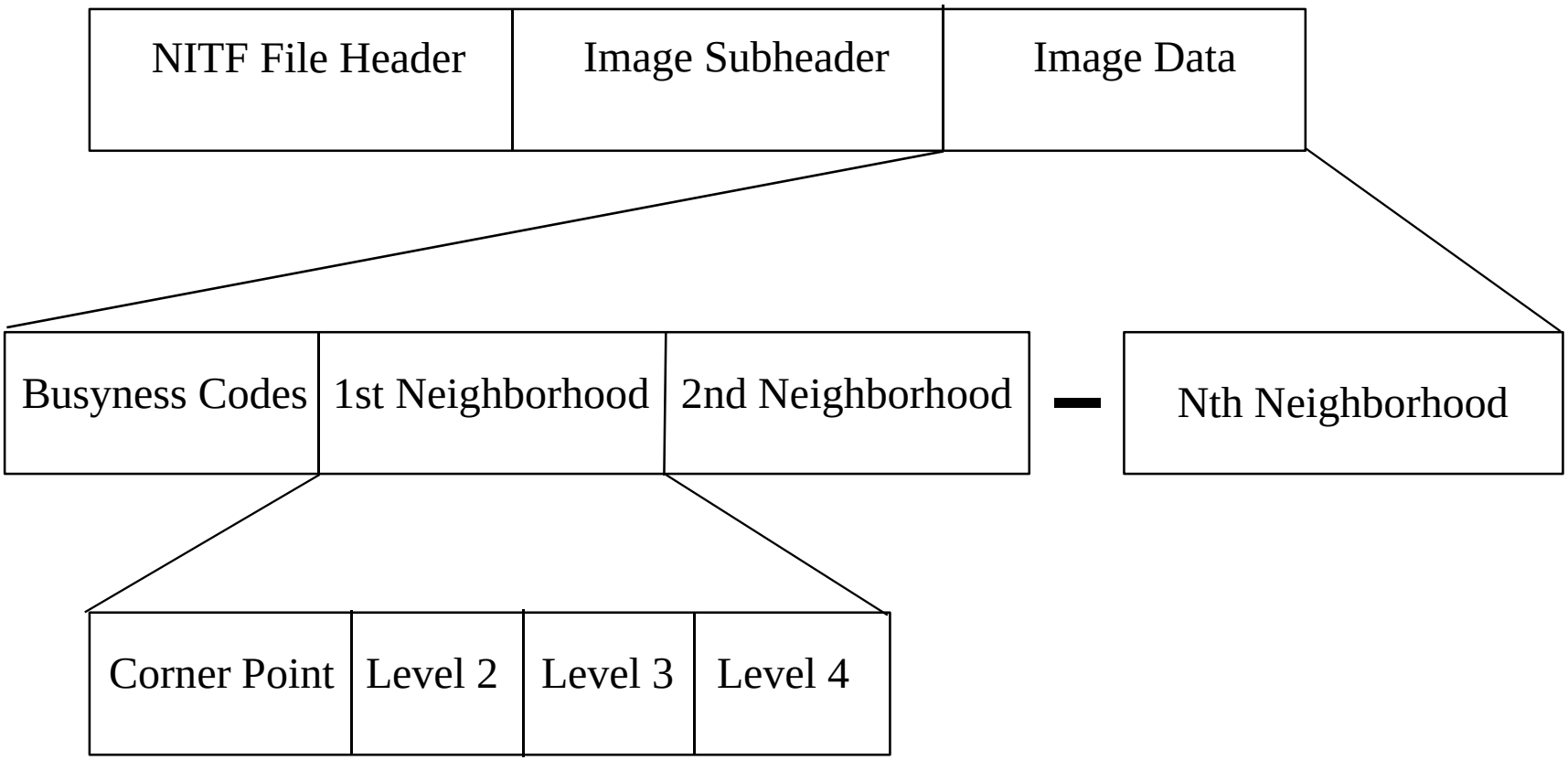


COMPRESSION

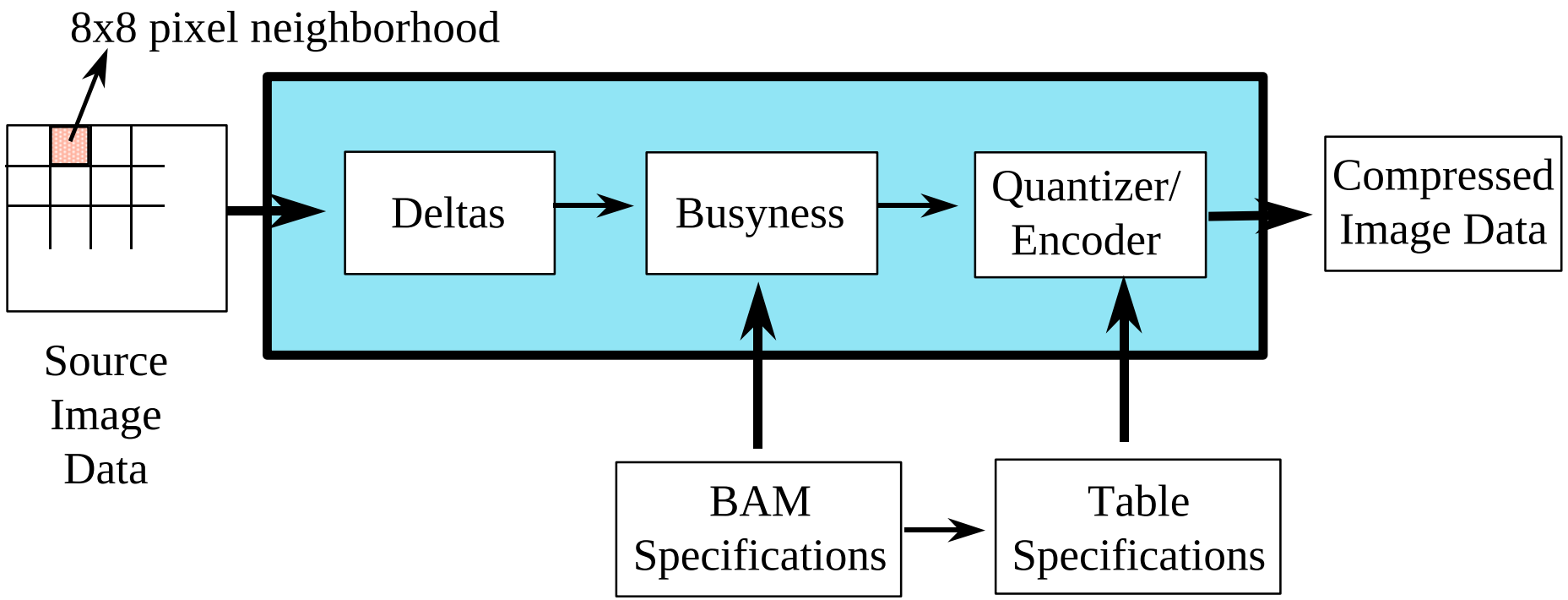
ARIDPCM

MIL-STD-188-197A

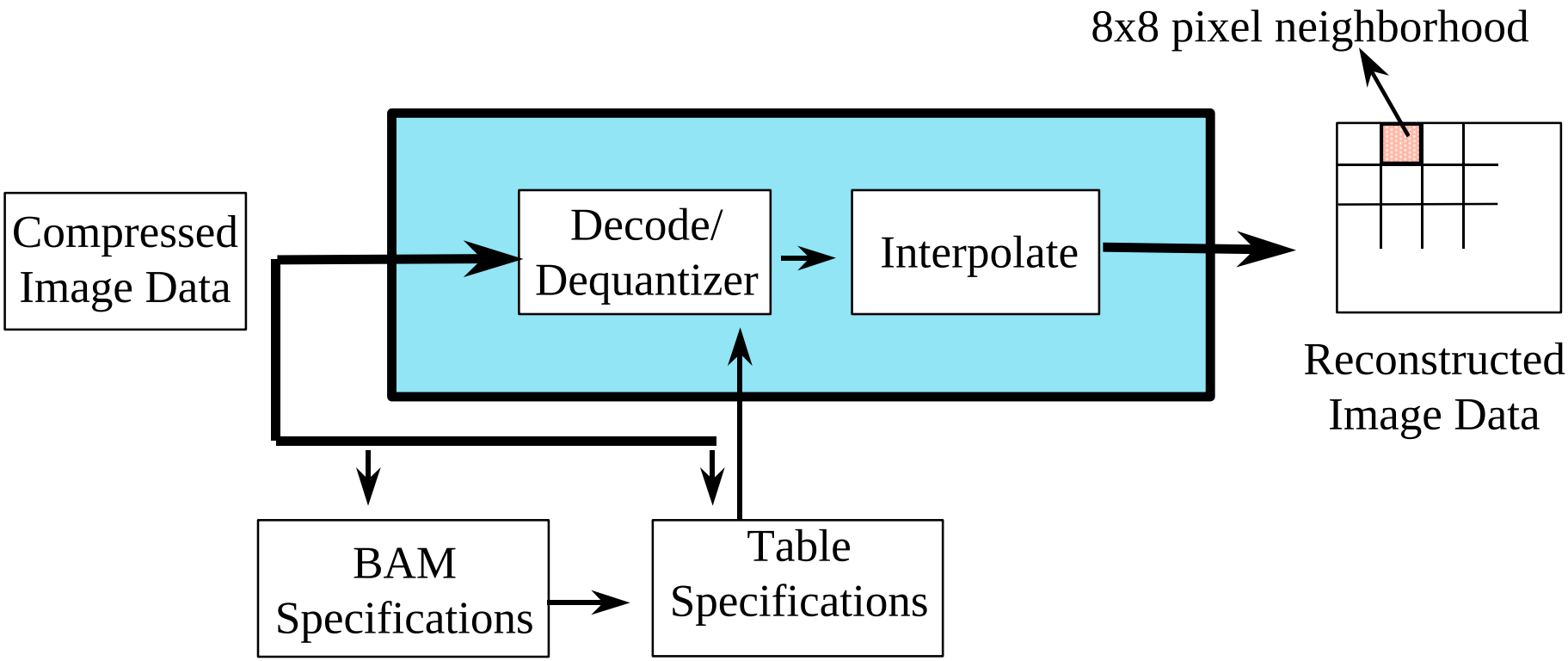
FORMAT OF A NITF 1.1 FILE (ARIDPCM)



ARIDPCM - BASED ENCODER



ARIDPCM - BASED DECODER



COMPRESSION

JPEG 2000

ISO/IEC 15444

JPEG2000 Standard Status

- The standard only specifies a decoder and a bitstream syntax and is issued in several parts:
  - **Part I:** Specifies the minimum compliant decoder (a decoder that is expected to satisfy 80% of applications); International Standard (IS) has been approved 1/3/01. Document available on Web (FCD version).
  - **Part II:** Describes optional, value added extensions; IS is expected in 12/2001 (delayed because of lack of work from international countries).
  - **Other parts include:** Motion JPEG2000 (Part III, CD 3/01); Conformance Testing (Part IV, CD 3/01); reference software in JAVA and C (Part V, FCD 3/01); file format for compound images (Part VI, CD 6/01).

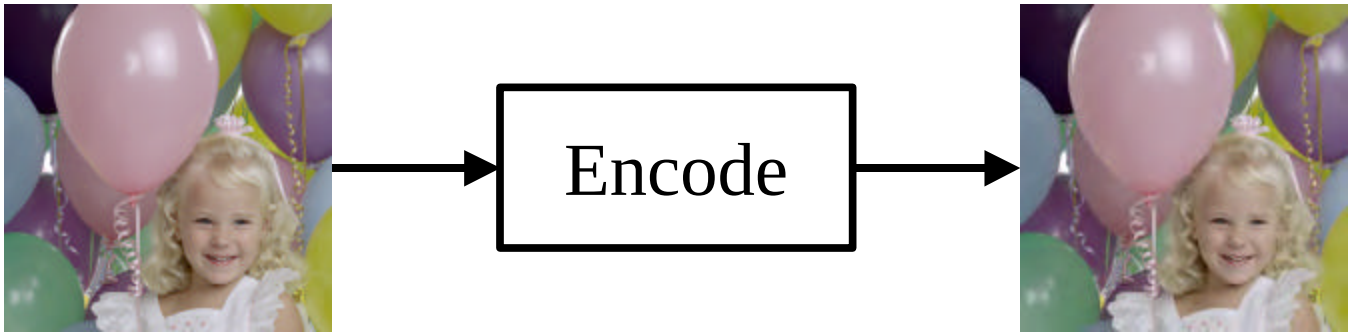
J2K Standard Status (cont.)

- **JPEG 2000 Part 2 Extensions**
  - Multiple component compression
  - Only a few people interested in the multiple component compression
  - Very limited budgets and very few customer support
  - No commercial interest
  - Near completion but needs to be finalized and tested
  - About 1 year more of work and meetings
- **JPEG 2000 Part 4 Compliance testing**
  - Critical that the compliance testing and levels are defined to establish the interoperability between commercial implementations (and NITFS)
  - NITFS testing is easier if the commercial testing and levels support USIGS requirements
  - About 1½ years left before completion of the standard

J2K Standard Status (cont.)

- **JPEG 2000 Part 3 Motion imagery**
  - USIGS is not involved in the standard
  - Motion is focused on sequence collection for digital cameras
  - Is being evaluated for applications in Digital Cinema
  - Would be useful in aerial motion imagery
    - Better quality and less complexity
- **JPEG 2000 Part 5 Example software**
  - Editor was replaced because of issues
  - Currently at FCD (not available)
  - Several people evaluating the software
  - This part is very important for commercial acceptance
  - The Independent JPEG Group (IJG) and the software that they produced was the main reason why JPEG is so successful
    - IJG is the basis of most commercial packages

Old Compression Paradigm (JPEG Baseline)



Encoder choices

color space
quantization
entropy coder
pre-processing

No decoder choices

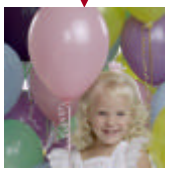
only one image
post-processing

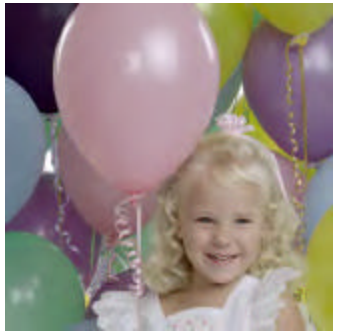
NEW COMPRESSION PARADIGM

Encode choices

Old paradigm choices +
Contone or binary
Tiling
Lossy/lossless

Encode





Decode choices

Image resolution
SNR fidelity
Visual fidelity
Target filesize
Lossless/lossy
Region-of-interest

SNR SCALABILITY EXAMPLE

All images have been decompressed from the same bit-stream

RESOLUTION PROGRESSIVE EXAMPLE

All images have been decompressed from the same bit stream. The wavelet decomposition provides a natural resolution hierarchy.

REGION OF INTEREST (ROI) EXAMPLE

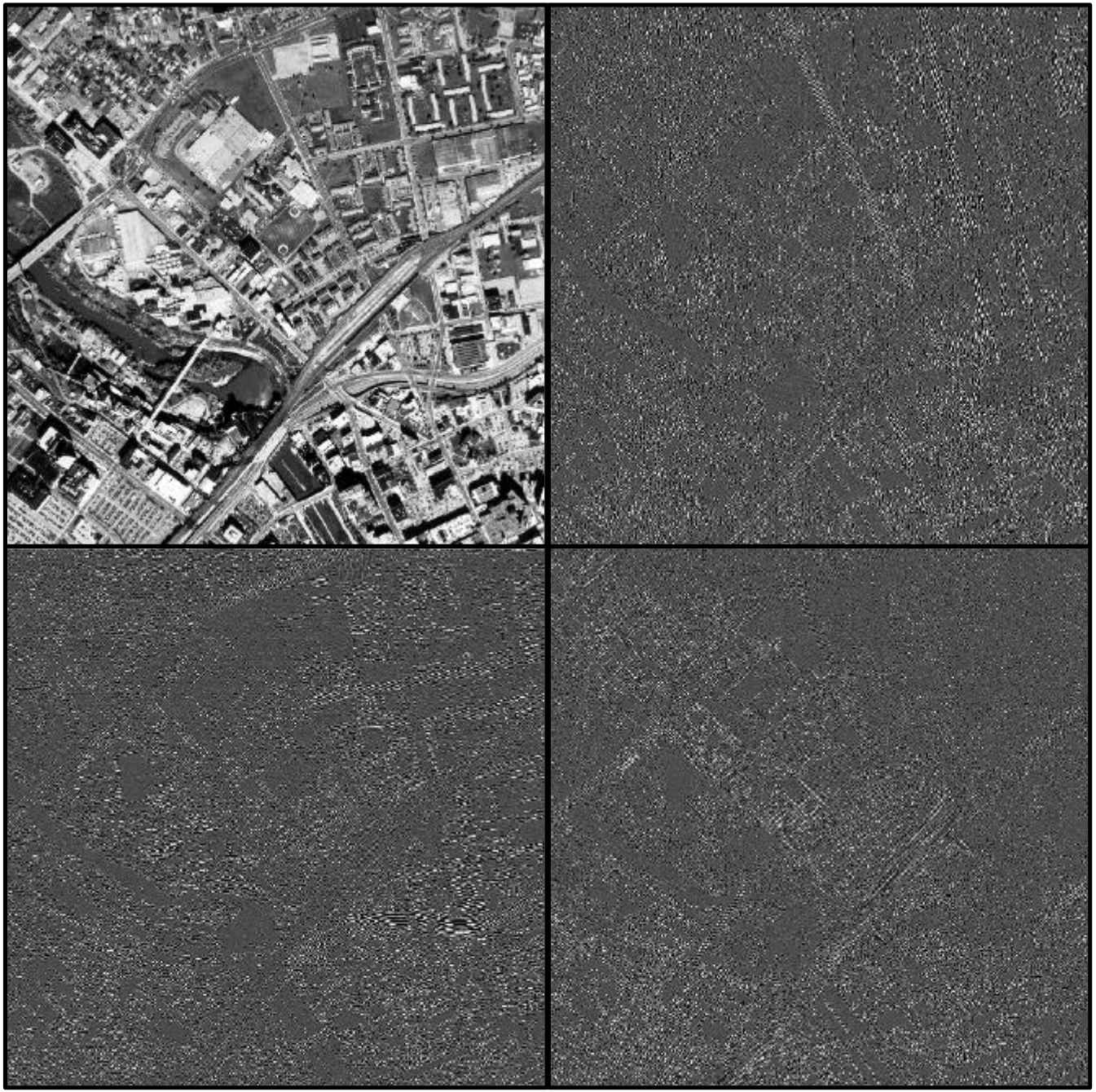
ROI has bit rate of 2.0 bpp

Rest of image has bit rate of 0.0625 bpp

Bit rate for entire image is 0.12 bpp

Original
1024-by-1024

Low-Low

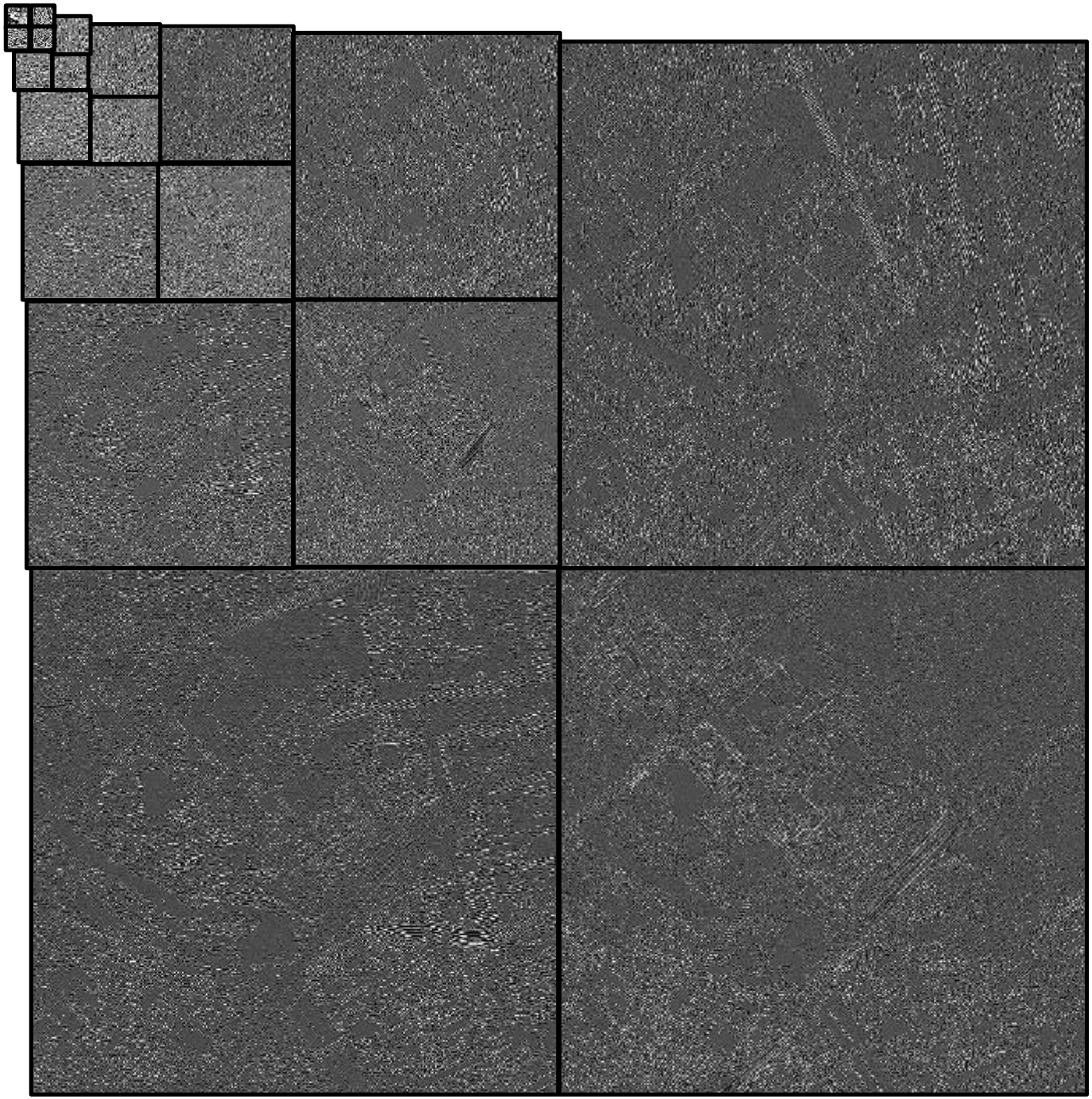


High-Low

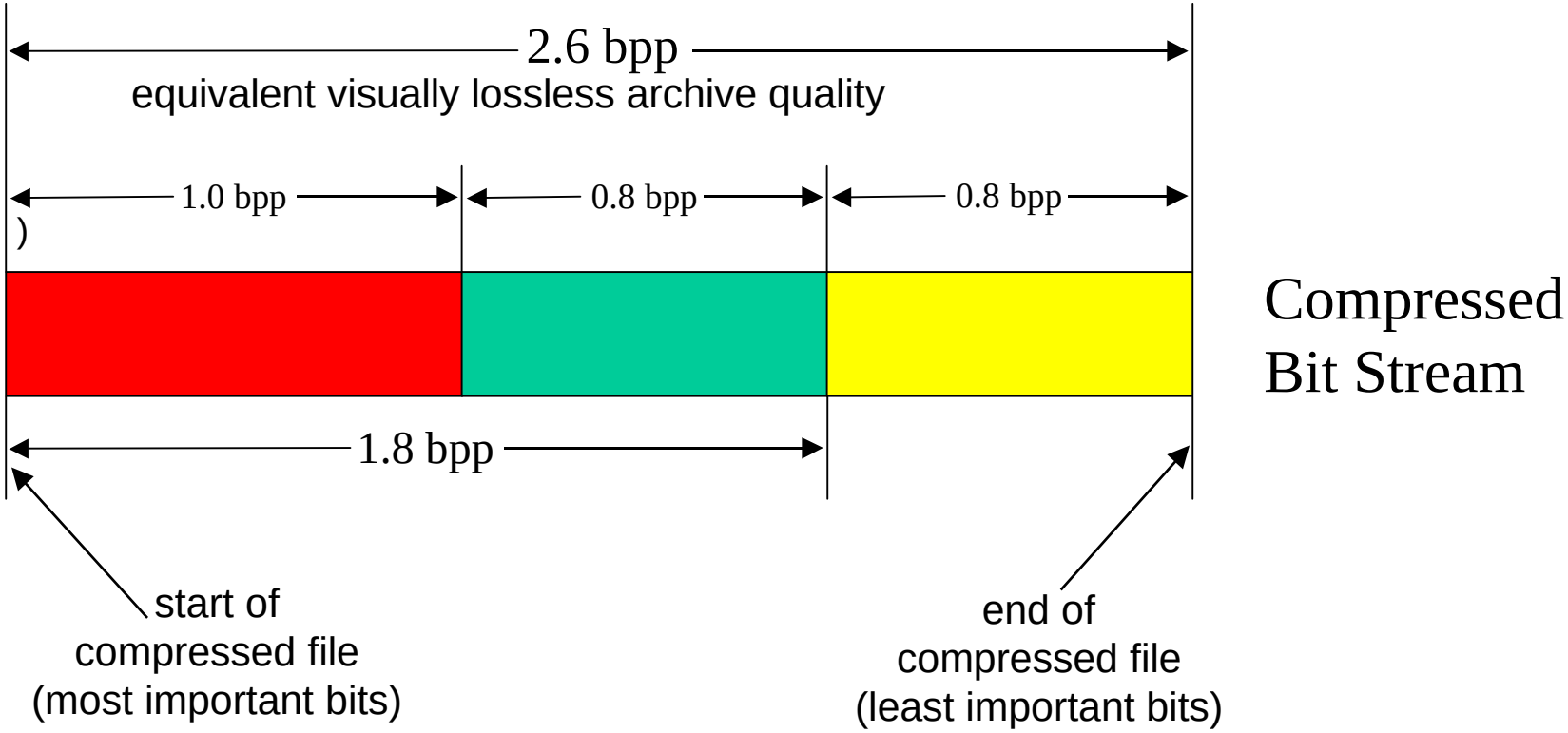
Low-High

High-High

Wavelet Pyramid decomposition



Embedded Bit Stream Example



Compress to a very high quality (rate). Then, any quality (rate) less than that can be obtained by truncating compressed bit stream.

COMPRESSION - FUTURE

MULTI-SPECTRAL - Correlated

HYPER-SPECTRAL

ELEVATION DATA

COMPLEX DATA

ANNOTATIONS

- Graphics/Symbols
  - CGM
  - Bit-Mapped (Legacy)
- Labels (Legacy)
- Text
- Audio (Future)
- Motion Imagery (Future)